VEGETATION IN RELATION TO SUBSTRATE AT JOHN FORREST NATIONAL PARK, WESTERN AUSTRALIA

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ABSTRACT

John Forrest National Park is dominated by an open forest of Jarrah (*Eucalyptus marginata*) on nutrient poor laterite with numerous granite outcrops which are surrounded by a mosaic of vegetation on a nutrient depleted skeletal soil. On the slopes are stands of Wandoo (*E. wandoo*) woodland confined to epidiorite (dolerite) dykes which form a dark red, relatively nutrient rich, shallow soil. The granite outcrop vegetation is the richest of a generally species poor, but weed free, forest area. Proteaceae is the family best representated in the Park's flora.

INTRODUCTION

John Forrest National Park (M21) was the first Western Australian National Park (created 1900) though it was originally known as Greenmount National Park but changed to its present name in 1928. It is located on the crest of the Darling Range escarpment 25km east of Perth, north of the Great Eastern Highway, Western Australia and consisits of several steep gradient hills and ridges. The Park is "reserved" for Parks and Recreation under the Metropolitan Region Scheme, as part of a system of "reserved" land extending through Greenmount to Helena Valley (M34). In 1992 it was vested in the National Park and Nature Conservation Authority managed by the department of Conservation and Land Management and extended to include the northern section and now occupies an area of 2676 hectares.

The National Park is composed of predominantly laterite soils carrying open forest and woodland of Jarrah (*Eucalyptus marginata*) and Marri (*E. calophylla*). Wandoo (*E. wandoo*) pre-dominates in epidioritic (doleritic) soil with a few small Jarrah and Marri, present as dyke intrusions that occur frequently in the granite and gneiss, representing 15% of the basement material (Malcahy, 1980). The skeletal soils of the granite outcrops consist of variable and complex soil associations.

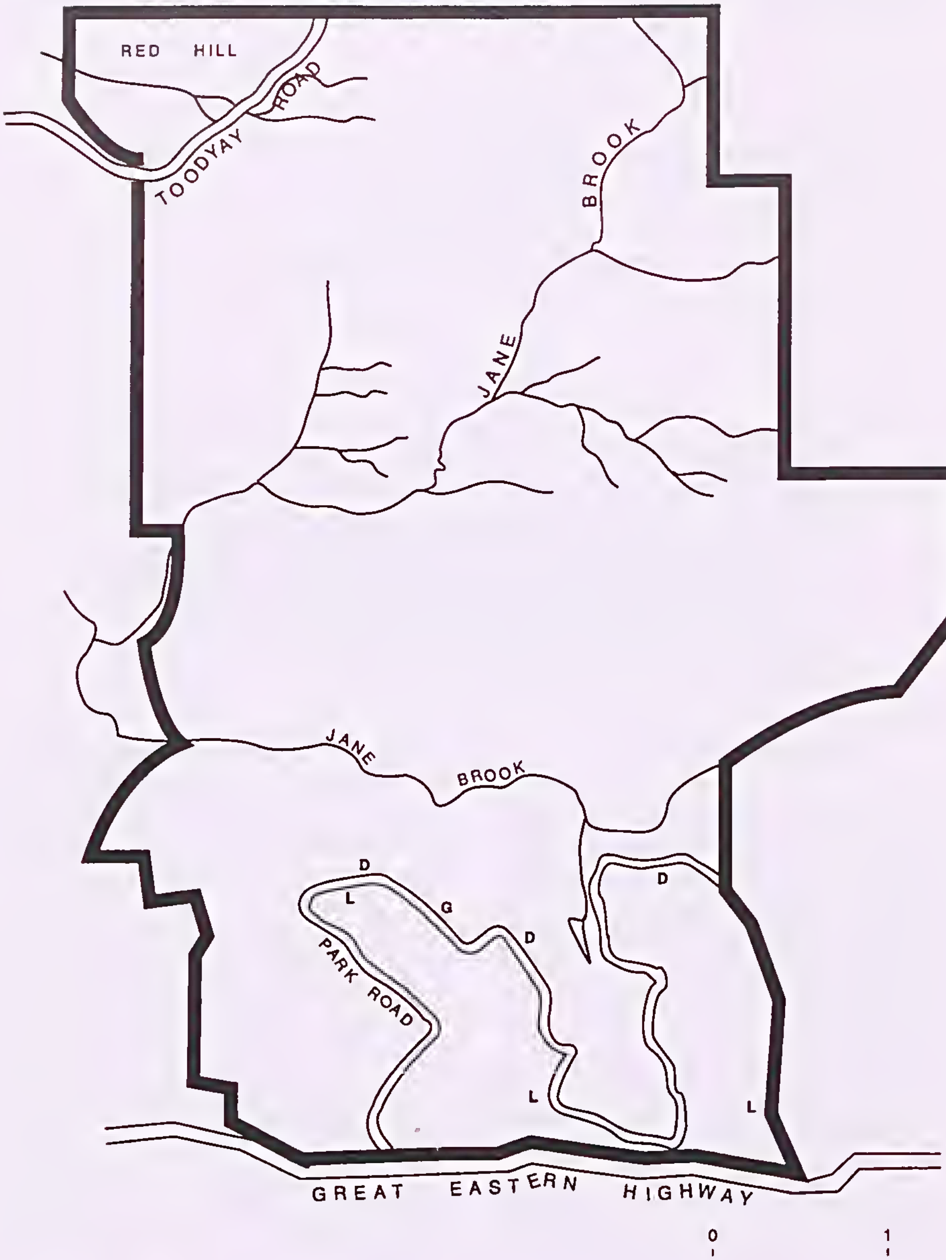

Figure 1. Plan of John Forrest National Park and location of study areas. (D=dolerite, G=granite outcrop, L=laterite).

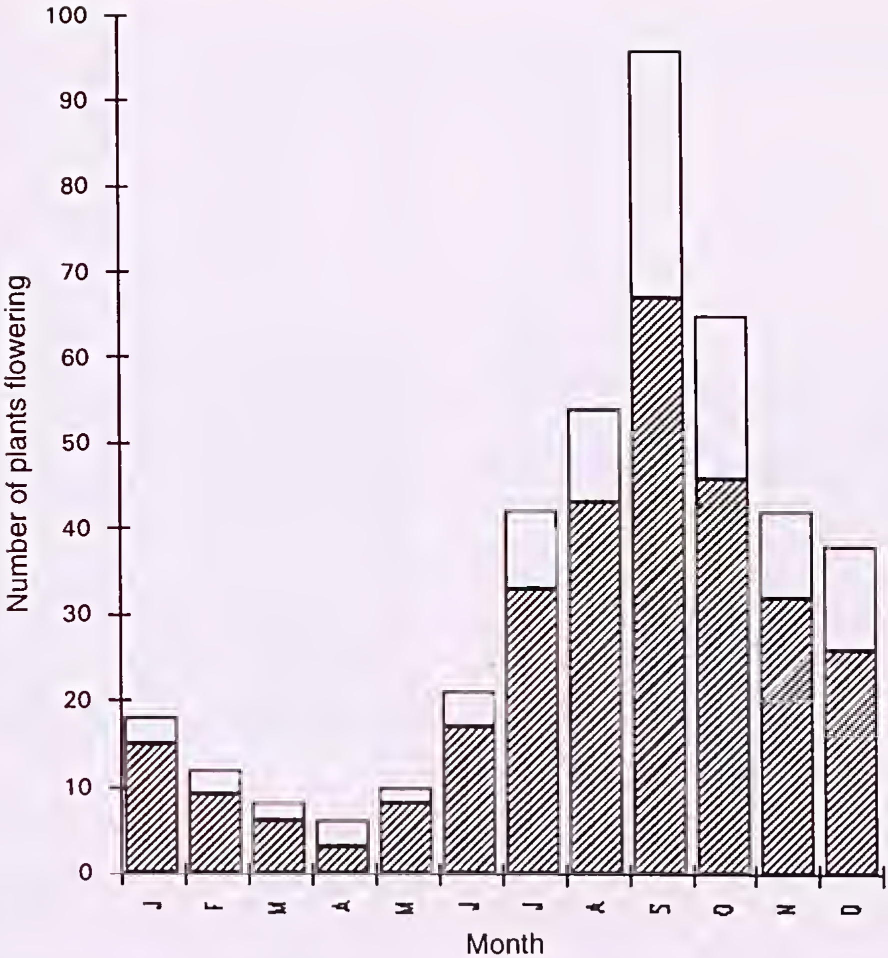

Figure 2. Number of woody and herbaceous plant species in flower each month (hatched = woody, open = herbaceous).

The recent extension to the north of the Park is dissected by several winter creeks. It carries Jarrah, Marri and Wandoo with extensive areas of scarp vegetation around granite outcrops containing stands of Rock Sheoak (*Allocasuarina fraseriana*) on Red Hill.

Within the park the scarp flora is generally poorly represented (Beard, 1981). The north-western Jarrah forest consists of a xerosere from high forest on deep soils to mosses and lichens on granite outcrops (Speck, 1958). Williams (1932, 1945) surveyed a strongly dissected area near John Forrest N.P. and described several associations and consociations, the latter consisting of single tree dominated communities. These consociations included Jarrah, Marri, Wandoo and Blackbutt (*Eucalyptus*

Table 1. Total number of species and number of species $500m^{-2}$ (brackets).

	Shrubs & Trees	Introduced herbs	Native herbs	Total
Laterite	77 (26)	4 (1)	51 (140	132 (41)
Dolerite	48 (22)	6 (2)	25 (13)	79 (37)
Granite	51 (32)	5 (3)	43 (30)	99 (65)
TOTAL	122	12	79	213

patens). These were related to underlying soils/rocks. However, he concluded that the units were too heterogeneous to be described as associations in the narrow sense but better described as edaphic complexes.

Williams (1945) concluded that plant communities were indicative of soil conditions but that individual tree species, and in particular individual shrub species were of limited value for this purpose. The species complex of the lateritic uplands differed markedly from the species complex of the dissected landscape and the soils derived from granite and dolerite as well as the moist alluvium areas. There were distinct species associated with the granitic and doleritic soils eg., *Allocasuarina huegeliana* and *E. wandoo* respectively. *E. patens* was indicative of the moist valley loams but many species failed to show any edaphic preferences.

A detailed study of the understorey floristics of the Jarrah forest in the Darling Range has shown the feasibility of using plant indicators to define site conditions (Havel, 1975). Although the vegetation and the associated environmental factors formed a complex continuum it was possible to define vegetation types (segments) in terms of composition, structure and environmental features.

A flowering calendar constructed by Armstrong and Muir (1994) for 587 plant species found in the park showed a flowering peak in the spring.

Our study compared the vegetation of three clearly recognisable upland, high-rainfall site types based on geological features (lateritic, doleritic and granitic outcrop) within the existing John Forrest National Park.

MATERIALS AND METHODS

Sample sites were subjectively located in areas of homogeneous, or undisturbed vegetation. Areas which offered mosaic habitats (e.g. granitic outcrop) were also sampled to gauge the vegetation variation. Each of the three sites was sampled (five times) during the entire year of 1988, using 10m x 10m quadrats (releves) and the cover-abundance estimated for the shrub species using the Braun-Blanquet cover-abundance scale (Mueller-Dombois & Ellenberg, 1974). From these data the Zurich-Montpellier method of ranking vegetation samples was used. Tree density and basal area per hectare was measured for all stems >4cm dbh.

Fortnightly visits to check flowering periods of the species at each site was undertaken and the species nomenclature follows Green (1985) for most vascular plants.

Litter retained by a one mm sieve was gathered (5 samples) from within a m² quadrat and oven dried at 95°C to constant weight.

Five soil samples, one from each of the replicate vegetation plots, from the surface 10 cm were collected.and oven dried at 95°C. Spectrophotometric determination was undertaken on sodium bicarbonate extractable potassium and available phosphorus (Colwell, 1963), organic carbon (by the Walkley-Black method, Nelson & Sommers, 1982) and KCl-extractable ammonium nitrogen. The water soluble nitrate nitrogen was analysed with a nitrate specific ion electrode at 25°C and the chloride with a Cl-ion electrode.

Reactive iron was extracted with ammonium oxalate-oxalic acid and measured by atomic absorption. It should be noted that this method provides a measure of the amount of iron that will react with phosphate in the soil but is not an indication of the iron available to the plant. E.D.T.P.A-extractable Cu, Zn and Mn were measured by atomic absorption.

RESULTS

The Darling Range in the Mundaring region has a dry Mediterranean climate with an average annual rainfall of c 1088 mm per year. Most of the rain falls in the winter during the months from May to August (66.2%). Winters are mild (mean temperatures: maximum 15.7°C, minimum 8.3°C), and summers are warm to hot (mean temperatures: maximum 29.4°C, minimum 15.8°C).

The total number of plant species in ther sampled plots was 213 of which 122 were shrubs. Only 12 of the 91 herbaceous plants were introduced species. (Appendix). The laterite area possessed the greatest number of species.

Most plants were in flower during September and October, particularly the shrubs, while the dry summer months showed a rapid fall off in flowering (Figure 1). Highest species richness was recorded for the

Table 2. Number of tree stems (4 cm diameter) at dbh and basal area (m²) per hectare.

Species	Laterite Stems	Laterite Basal area	Dolerite Stems	Dolerite Basal area	Granite Stems	Granite Basal area
Eucalyptus marginata	354.0	17.8	54.3	1.0	57.5	7.8
Eucalyptus calophylla	120.9	3.8	12.7	0.2	56.0	1.1
Eucalyptus wandoo	30.5	2.9	201.7	15.2	4.2	0.2
Allocasuarina fraseriana	28.3	0.6	0.0	0.0	2.0	0.0
Banksia grandis	10.4	0.4	0.0	0.0	0.0	0.0
TOTAL	524.1	24.5	268.7	16.4	119.7	9.1

heterogeneous granite areas on and around the large outcrops. Much of the difference between the laterite, dolerite and the granite was due to the large number of annuals found in the shallow granitic soils during September and October (15 compared to four and three). The cover of the ground vegetation also differed little; the most complete cover was found on the dolerite (102% cover/abundance) while the cover on the laterite and granite was approximately equal (87% and 82% respectively).

The greatest density difference occurred in the tree canopy (Table 2). The upland lateritic plateau, dominated by Jarrah, was by far the most dense. While all three Eucalypts were also found around the granite outcrops they were much smaller, thinner specimens. On the other hand Wandoo dominated the doleritic soils with few Jarrah and Marri present. The amount of litter found on the forest floor did not coincide with the tree density but was related to the overall density of vegetation as there was only marginally more in the lateritic zones (Table 3) than the other two areas. All the soils were shallow but the doleritic and granitic lithosols were only about half as deep as the more developed laterite.

Table 3. Soil depth (cm) and dry mass of litter (g m^{-2}).

	No. of Samples	Laterite	Dolerite	Granite
Soil depth	50	26.3	14.3	14.9
Litter	10	177.1	136.4	139.8

The three soils all had similar pH values, C, Cl, and Zn, contents (Table 4). While the granitic and lateritic soils were identical in C, Cu, and NO_3-N, values on the dolerite for these were slightly higher. However, the doleritic soil is about three times as rich in K, Fe, and Mn. The NH_4-N, and P, content of the laterite was slightly less than that of the other two areas. Below the lateritic

Table 4. Soil carbon, pH and nutrient content (ug g^{-1}). All samples were from the surface except the lower pallid zone which was several metres deep (after Foulds 1993).

	Symbol	Laterite	Pallid Zone	Granite	Dolerite
pH		6.1	5.0	5.9	6.3
Carbon	(C)	1.7	–	1.6	2.4
Phosphorus	(P)	3.4	1.6	4.8	5.4
Potassium	(K)	48.8	10.8	87.0	285.7
Nitrate-nitrogen	(NO_3-N)	2.8	2.0	2.7	5.7
Ammonium-nitrogen	(NH_4-N)	2.9	–	10.0	7.4
Iron	(Fe)	565.0	–	410.0	1648.0
Chloride	(Cl)	93.0	156.0	112.0	112.0
Copper	(Cu)	0.3	–	0.6	2.8
Zinc	(Zn)	0.7	–	0.6	0.8
Manganese	(Mn)	9.2	–	7.1	41.0

duricrust is a white, pallid zone often several metres deep. This contains much less P, K and NO_3-N than the surface layer though Cl values are greater (Table 4).

DISCUSSION

The vegetation sites of the John Forrest National Park do not conform exactly with any of Havel's (1975) site-vegetation types of the Northern Jarrah Forest (Darling Range) in terms of floristic composition and structure. However, they appear to be somewhat related to Segment S (orange heavy gravels on slopes and plateaus in medium high-rainfall zones with predominantly dense stand of Jarrah; some Marri and a second storey of *Banksia grandis* and *Allocasuarina fraseriana*) and Segment P (gravelly sand on mid-slopes and strong development of a second storey of *A. fraseriana* and *B. grandis*) less frequently. The dolerite sites are unrelated to any of the Havel types though it does show soil similarities to segment M in being red clay loam. The tree layer of segment M is predominantly Wandoo but at John Forrest there is a reasonably developed understorey whereas the eastern vegetation site type had no second storey. There were no granite vegetation sites described by Havel.

The differentiating species (indicator species), derived from the Braun-Blanquet cover-abundance data, were *Adenanthos barbigerus*, *Hakea amplexicaulis* and *Petrophile striata* for the laterite area , *Hibbertia cuneiformis* and *Hypocalymma robustum* for the dolerite region and *Hakea stenocarpa*, *Hakea trifurcata*

Table 5. Species richness of selected Western Australian and Eastern Australian heathlands, woodlands and open forests.

Habitat	Location	No. species	No. families	No. aliens	No. species $500m^{-2}$
Wandoo woodland	Parker's Range	56	25	0	53 A
Banksia woodland	Pinnaroo Park	184	46	40	44 B
Granite outcrop	Duladgin	69	22	6	65 A
Laterite heathland	Corackerup Nature reserve	–	–	–	62 D
Laterite heathland	Leeman	108	31	2	48 C
Sand (over laterite) heathland	Eneabba Nature Reserve	–	–	–	92 D
Jarrah–Marri open – forest	Western Australia	–	–	–	43 D
Wandoo woodland	Western Australia	–	–	–	35D
Open – forest and woodland	Eastern Australia	–	–	–	40D

A, After Foulds, 1988a; B, After Foulds, 1988b; C, After Foulds and McMillan, 1985; D, After George *et al.*, 1979 and *Verticordia pennigera* for the granite outcrop.

The South West Botanical Province of Western Australia is noted for its floristic richness and high degree of endemism (Gardner, 1944; Burbidge, 1960). Although open-forest (mainly Jarrah) and woodland cover almost half the Province these are relatively species poor (Table 5). The greatest number are found on the heathlands (George, Hopkins and Marchant, 1979). The species-richness value (taking the number of species $500m^{-2}$ as the criterion for richness) of Western Australian open-forests (43 species) in general (Table 6) is identical with that found on the laterite at John Forest National Park (41 species). The open-forest and woodland values are also similar in the eastern Australian states (George et al., 1979). The Metropolitan woodlands such as a Banksia woodland at Pinnaroo Valley Memorial Park, Western Australia (Foulds 1988a) also has a relatively low value (44). By comparison the heathland habitats growing on laterite have, as previously stated, much larger values, ranging from 48 to 92.

The granitic outcrop possessed the richest flora (65 species $500m^{-2}$) in the John Forrest National Park owing to a large number of winter annuals. This was exactly the value obtained at a large granitic outcrop at Duladgin, Western Australia (Foulds unpub. data) despite the much lower rainfall of this more eastern lithic complex (Southern Cross; 279mm per annum). The high value at Duladgin is also due to more than half the species being ephemerals (36).

The Wandoo dominated woodlands east of the Jarrah forest was considered to be a depauperate version of the Jarrah undergrowth and more xerophytic in nature (Diels, 1906). However, this would appear not to be the case, as an Eastern Goldfields Wandoo woodland at Parker's Range (with an exposed pallid zone) is more species rich, 57 species $500m^{-2}$ (Foulds, 1988b), than both Wandoo and Jarrah forests and woodlands of Western Australia generally,

Table 6. Soil nutrient of selected W.A. soils.

Habitat	Location	pH	C %	P	K	NO_3	NH_4	Fe ug g-1	Cl	Cu	Zn	Mn
Wandoo woodland	Parker's Range	6.1	1.3	0.3	118.5	15.5	10.9	495	309	–	–	–
Banksia woodland	Pinnaroo Park	7.0	0.9	3.0	24.8	8.2	–	–	20	0.3	0.5	2.1
Granitic outcrop	Duladgin	6.3	0.8	4.8	157.0	8.6	26.2	314	69	–	–	–
Salmon Gum	Duladgin woodland	8.2	0.7	2.9	426.0	13.8	19.0	265	48	–	–	–
Jarrah forest	Mayanup	6.3	–	3.0	45.5	2.2	–	–	20	0.1	02	1.9
Laterite heath	Leeman	6.9	0.6	2.0	48.2	3.8	32.2	140	38	0.2	2.6	3.3

including those at John Forrest National Park (Table 5). This is despite the much lower annual rainfall (Southern Cross, 279mm per annum) and paucity of some nutrients (Table 6). Therefore the distribution of Wandoo (*E. wandoo*) seems to depend upon the fertility (particularly the high K content) and heavy texture of the soil (Havel, 1975).

Unlike Wandoo, Jarrah does not grow east of the 500mm isohyet, but is replaced by Salmon Gum (*Eucalyptus salmonophloia*) and Gimlet (*Eucalyptus salubris*). These grow on calcareous alkaline soils much richer in nutrients such as N and K (Table 6). They contain a less dense undergrowth of shrubs but are equally species rich (43 species 500 m^{-2}, Foulds, 1988b).

The species richness described above is very much smaller than the 587 species obtained by Armstrong and Muir (1994), but the latter data is total number in the park, giving no indication of number per unit area.

The relative contribution of major families to the flora at John Forrest is similar to that of other Western Australian habitats (Table 7) such as limestone and lateritic heathlands. By comparison the Eastern Australian heathlands and woodlands are rich in Epacridaceae but less dominated by Myrtaceae and Proteaceae. Lateritic soils of Western Australia are particularly rich in members of Proteaceae (30%).

The dominance of this family on these infertile soils may be due to the presence of proteoid roots (Lamont, 1981) which are thought to

Table 7. Percentage contribution by nine major families to total number of species at the sub association level and above as calculated from the 10 x 10 releves using the Zurich-Montpellier system of analysis.

	John Forest National Park W. Australia	S-E Victorian heath and woodland[A]	S-E W.A. limestone heath[A]	Leeman. W.A. laterite heath[B]
% Contribution by	29	49	41	36
Myrtceae	17.2	8.2	12.2	13.9
Leguminoceae (+ Mimosaceae)	13.8	18.3	14.6	16.7
Epacridaeae	3.4	10.2	2.4	2.8
Proteaceae	31.0	4.0	12.2	27.8
Cyperaceae	0.0	4.0	7.3	2.8
Restionaceae	3.4	6.1	2.4	8.3
Euphobiaceae	0.0	2.0	2.4	0.0
Liliaceae (+Xanthorrhoeaceae)	6.0	4.0	4.9	5.6
Goodeniaceae	0.0	2.0	2.4	2.8
Others	27.5	41.2	39.2	19.4

A After Bidgewater & Zammit, 1979
B After Foulds and McMillan, 1985

increase the efficiency of ion uptake, or at least increase the root area in contact with the soil solution (Jeffrey, 1967) thus maximising mineral absorption.

The success of the Jarrah (and marri) on the laterite may be due to a modified root system (Dell, Bartle & Tacey, 1983). These consist of sinker roots, initiated from major laterals, which descend through fissures in the caprock entering distinct vertical channels that pass through the friable bauxitic layer and into the pallid zone. As many as 100–200 of these channels are available to each tree (they are absent from profiles derived from dolerite) and may play a role in the water and salt balance of Jarrah forests on lateritic (granite derived) profiles.

The lateritic ironstone gravel soils of the Darling Range share nutritional problems with the lateritic sandplain soils of the drier eastern zone. The topsoils are deficient in N and P, as well as the trace elements Cu, Zn and Mn (Mulcahy, 1981). This is the case with the John Forrest laterite whereas the Salmon Gum woodland found on a typical Yilgarn lateritic sandplain is much richer in N and particularly K. The granitic outcrop is identical with a more eastern lithosol at Duladgin, both soils being deficient in most nutrients except K and N.

Though not as rich as the Salmon Gum woodland the Wandoo woodland soils derived from the dolerite are richer than the heaths, Banksia woodlands and the other two soil types tested in the John Forrest National Park. This may be due to a greater mineral content, retention and base exchange capacity of the soil.

There was a strong relationship between tissue nutrient concentration and the concentration of the nutrient in the soil (Table 4 and 8, Foulds, 1993). The concentrations of N, P, and K in the tissues of the dolerite species was significantly higher than those of the tissues of plants in the laterite soils (Foulds, 1993). The granite soils and plant shoots were both similarly depleted in nutrients in concentrations similar to those of the laterite habitat and significantly less rich than the substrate and tissues of the dolerite plants. The litter from the plants of the respective areas were indicative of the concentrations found in the shoot tissues (Table 8).

These John Forrest soils support open forest of average tree density

Table 8. Mean nutrient status of shoots of the plant species a the selected sites.

Soil type Species	($mg\,g^{-1}$)			($\mu g\,g^{-1}$)		
	N	P	K	Cu	Zn	Mn
LATERITE	7.5	0.3	5.5	4.0	10.7	127.7
Litter	5.9	0.2	0.6	6.5	20.9	86.5
DOLERITE	10.5	0.4	7.5	8.8	18.7	131.0
Litter	5.6	0.4	0.6	9.9	23.0	141.5
GRANITE	5.9	0.4	5.5	5.6	14.4	48.7
Litter	6.0	0.3	0.6	5.9	23.3	148.0

with numerous rock outcrops, which although containing relatively few species have despite the recreational nature of the area few introduced species (12). This compares favourably with other Parks used by the public such as Pinnaroo (Foulds, 1988a) which contains a far higher number (40) and density of alien plants. This supports the suggestion by Specht (1981) and verified from laterite heath studies (Foulds & McMillan, 1985) that the invasion by herbs is most marked on sandy soils while laterite soils are more weed free.

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APPENDIX

Species list, flowering period, presence/absence of plants at John Forrest National Park.
F = fern, + = present, – = absent, * = introduced species.

	FAMILY GENUS / SPECIES	FLOWERING TIME	LATERITE	DOLERITE	GRANITE
	ADIANTACEAE				
F	*Cheilanthes austrotenuifolia*	–	+	+	
	CYCADACEAE				
	Macrozamia riedlei	Oct–Mar	+	+	+
	POACEAE				
*	*Briza maxima*	Sept	–	+	+
*	*Briza minor*	Sept–Oct	–	–	+
	Neurachne alopecurioidea	Aug–Sept	+	–	+
	Pentaschistis airoides	Sept–Oct	–	–	+
	Stipa compressa	Sept–Oct	–	–	+
	CYPERACEAE				
	Cyperaceae indet.	D.N.F.	–	+	–
	Lepidosperma angustatum	Nov–Dec	+	–	+
	Lepidosperma gracile	Dec–Jan	+	–	–
	Mesomelaena tetragona	Apr–Sept	–	–	+
	Tetraria octandra	Sept–Nov	–	–	+
	RESTIONACEAE				
	Loxocarya flexuosa	Mar	–	+	+
	DASYPOGONACEAE				
	Lomandra endlicheri	May–Aug	+	–	–
	Lomandra multiflora	Jun–Jul	+	–	–
	XANTHORRHOEACEAE				
	Xanthorrhoea preissii	Sept–Oct	+	+	+
	PHORMIACEAE				
	Dianella revoluta	Sept–Oct	+	+	+
	Stypandra imbricata	Sept–Jan	+	–	–
	ANTHERICACEAE				
	Arthropodium capillipes	Jan	+	–	–
	Borya nitida	Sept–Oct	–	+	+
	Chamaescilla corymbosa	Aug–Sept	+	–	–
	Thysanotus multiflorus	Sept–Oct	+	–	–
	Trichoryne elatior	Feb	–	–	+
	COLCHICACEAE				
	Burchardia umbellata	Aug–Sept	+	+	+
	HAEMODORACEAE				
	Anigozanthos humilis	Oct	+	–	–
	Anigozanthos manglesii	Sept	+	–	–
	Conostylis androstemma	July–Aug	–	+	+
	Conostylis carcina	Sept–Dec	+	–	–
	Constylis setigera	Nov	–	–	+

FAMILY GENUS / SPECIES	FLOWERING TIME	LATERITE	DOLERITE	GRANITE
Conostylis setosa	Sept	–	+	+
Conostylis spinuligera	Sept	–	+	+
Conostylis teretifolia	Jul–Sept	+	+	–
Haemodorum corymbosum	Dec	+	+	+
AMARYLLIDACEAE				
Hypoxis leptantha	Sept	+	–	–
DIOSCOREACEAE				
Dioscorea hastifolia	Apr–Oct	–	+	+
IRIDACEAE				
* *Freesia refracta*	Sept–Oct	+	–	+
* *Patersonia sericea* var. *rudis*	Sept–Dec	+	–	–
* *Romulea rosea*	Aug	+	–	–
ORCHIDACEAE				
Caladenia deformis	July	+	+	+
Caladenia patersonii var. *longicauda*	Sept	+	+	+
Diuris longifolia	Jul–Sept	–	+	+
Prasophyllum hians	Sept	+	–	–
Pterostylis barbata	Aug	+	+	–
Pterostylis recurva	July	+	–	–
Thelymitra antennifera	Sept	–	+	–
CASUARINACEAE				
Allocasuarina humilis	Jul–Sept	+	–	–
Allocasuarina fraseriana	Aug–Sept	+	–	+
PROTEACEAE				
Adenanthos barbigerus	Jan–Dec	+	–	–
Banksia grandis	Sept–Oct	+	–	–
Conospermum crassinervium	Oct–Dec	–	+	+
Dryandra bipinnatifida	Oct	+	–	–
Dryandra nivea	Jun–Oct	+	+	+
Dryandra sessilis	Jun–Oct	+	–	–
Grevillea endlicheriana	July–Dec	+	+	+
Grevillea flexuosa	July–Sept	–	+	–
Grevillea glabrata	Jul	+	–	–
Grevillea pilulifera	Jul–Sept	+	–	–
Grevillea synapheae	Jul–Oct	+	–	–
Grevillea wilsonii	Oct–Dec	+	–	+
Hakea amplexicaulis	Aug–Oct	+	–	–
Hakea cristata	Sept–Oct	+	+	+
Hakea cylocarpa	May–Jun	+	–	–
Hakea erinacea	July	+	–	+
Hakea incrassata	July–Aug	–	–	+
Hakea laurina	July–Aug	+	+	+
Hakea lissocarpha	Jan–Jul	+	+	+
Hakea ruscifolia	Jan	+	–	–
Hakea stenocarpa	Sept–Nov	+	–	+

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Hakea trifurcata	Jul–Aug	+	–	+
Isopogon asper	Sept	–	–	+
Isopogon spaerocephalus	Mar–Oct	+	+	–
Persoonia elliptica	Oct–Jan	+	–	–
Persoonia saundersianna	DNF	+	–	–
Petrophile biloba	Aug	–	–	+
Petrophile striata	Oct–Dec	+	–	–
Synaphea petiolaris	Aug–Oct	+	+	–
Synaphea pinnata	DNF	–	+	–
Synaphea polymorpha	Sept	+	–	–
SANTALACEAE				
Leptomeria axillaris	Nov	+	+	–
AMARANTHACEAE				
Ptilotus caespitulosus	Dec–Mar	–	–	+
Ptilotus manglesii	Oct–Jan	+	–	+
RANUNCULACEAE				
Clematis aristata	Sept–Oct	–	–	+
LAURACEAE				
Cassytha flava	Dec	–	–	+
Cassytha pubescens	Dec	+	–	+
DROSERACEAE				
Drosera erythrorhiza	DNF	+	+	–
Drosera leucoblasta	Sept–Oct	–	–	+
Drosera menziesii	July–Aug	+	+	+
Drosera pallida	Sept	–	–	+
PITTOSPORACEAE				
Billardiera sp. indet.	Nov	–	+	–
Marianthus pictus	Feb	–	+	–
MIMOSACEAE				
Acacia lasiocarpa	July–Sept	–	+	–
Acacia obovata	June	+	–	–
Acacia pulchella	July–Sept	+	–	
Acacia stenoptera	Jan–Feb	+	–	–
Acacia teretifolis	May–Jun	+	–	–
Acacia diptera	July	+	–	–
PAPILIONACEAE				
Bossiaea eriocarpa	Aug–Oct	+	+	+
Bossiaea ornata	Sept–Oct	+	+	+
Daviesia horrida	July–Sept	+	–	+
Daviesia juncea	Jun–Aug	+	–	–
Daviesia pectinata	Jul–Oct	+	–	–
Daviesia polyphylla	Jul–Dec	+	+	+
Daviesia preissii	Dec–Feb	+	–	–
Gastrolobium calycinum	Jul–Nov	+	–	+
Gastrolobium ovalifolium	Aug–Sept	+	+	+

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Gomphobium marginatum	Nov	+	+	+
Gompholobium polymorphum	Sept–Nov	+	–	+
Gompholobium preissii	Nov–Dec	+	–	–
Gompholobium tomentosum	Sept–Dec	+	–	–
Hardenbergia comptoniana	Jul–Aug	+	–	–
Hovea chorizemifolia	May–Jun	+	+	–
Hovea pungens	Jul–Aug	–	+	–
Hovea trisperma	Jul–Aug	+	+	–
Isotropis cuneifolia	Sept–Nov	+	–	–
Jacksonia alata	Sept–Nov	–	–	+
Jacksonia restioides	Dec	+	–	–
Kennedia coccinea	Aug–Sept	+	–	–
Kennedia prostrata	Sept	–	–	+
Libichea punctata	Sept–Dec	+	–	–
* *Lupinus angustifolius*	Sept–Oct	–	+	+
Mirbelia spinosa	Sept	+	+	+
Oxylobium capitatum	Aug–Sept	–	–	+
Oxylobium cuneatum	Sept–Oct	–	+	–
Oxylobium cuneatum var *dilatatum*	Sept–Oct	–	+	–
Phyllota barbata	Jan–Apr	–	–	+
Pultenaea ericifolia	Sept–Oct	+	–	–
Sphaerolobium ulmineum	Sept	+	–	–
OXALIDACEEAE				
* *Oxalis pes-caprae*	Sept–Oct	–	+	+
LINACEAE				
* *Linum trigynum*	Dec	–	+	–
RUTACEAE				
Boronia cymosa	July	–	–	+
Boronia ovata	Sept–Nov	+	–	–
TREMANDRACEAE				
Tetratheca setigera	Aug–Dec	+	–	–
POLYGALACEAE				
Comesperma confertrum	Feb–Nov	+	–	–
EUPHORBIACEAE				
Phyllanthus calycinus	Aug–Sept	–	+	+
STACKHOUSIACEAE				
Stackhousia brunonis	Sept–Nov	–	+	+
SAPINDACEAE				
Diplopeltis huegelii	Sept	–	+	–
RHAMNACEAE				
Cryptandra arbutiflora	Aug	–	–	+
Trymalium ledifolium	Jun–Sept	+	+	+
Trymalium floribundum	Jul–Nov	–	+	+

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STERCULIACEAE				
Lasiopetalum floribundum	June–Oct	+	–	–
DILLENIACEA				
Hibbertia cuneiformis	Sept	–	+	–
Hibbertia depressa	Dec–Mar	+	–	–
Hibbertia hypericoides	Jun–Dec	+	+	+
Hibbertia lasiopus	Sept–Oct	+	+	–
Hibbertia montana	Jul–Nov	+	+	–
Hibbertia pachyrrhiza	Nov–Mar	+	–	–
Hibbertia racemosa	Sept	–	–	+
Hibbertia subvaginata	Sept	+	+	+
VIOLACEAE				
Hybanthus floribundus	June	+	–	–
THYMELAEACEAE				
Pimelea angustifolia	Sept	+	–	–
Pimelea rosea	Sept	+	–	–
Pimelea spectabilis	Sept–Nov	–	+	–
MYRTACEAE				
Baeckea camphorosmae	Dec–Mar	+	–	+
Beaufortia macrostemon	Jan	+	–	–
Beaufortia purpurea	Nov–Dec	+	–	–
Calothamus quadrifidus	Sept–Dec	–	+	–
Calothamus sanguineus	June	+	–	+
Calytrix glutinosa	Sept	+	–	+
Darwinia citriodora	Jul–Dec	–	+	–
Eucalyptus calophylla	Jan–Mar	+	+	+
Eucalyptus marginata	Jan	+	+	+
Eucalyptus wandoo	Oct–Nov	+	+	+
Hypocalymma angustifolium	Aug–Oct	–	+	–
Hypocalymma robustum	Aug–Dec	+	–	–
Melaleuca scabra	Sept–Oct	–	–	+
Verticordia pennigera	Dec	–	–	+
Verticordia plumosa	Dec	–	–	+
APIACEAE				
Actinotus aff. *leucocephalus*	Dec	+	–	+
Daucus glochidiatus	Sept–Oct	–	–	+
Platysace compressa	Mar–Apr	+	–	–
Platysace juncea	Dec–Feb	+	–	+
Trachymene pilosa	Sept–Oct	–	–	+
Xanthosia candida	Sept	+	–	–
EPACRIDACEAE				
Andersonia lehmanniana sub. sp. *lehmanniana*	May–Sept	–	+	–
Astroloma pallidum	May–Sept	+	–	–
Leucopogon capitellatus	Aug	+	–	+
Leucopogon gracillumis	Feb	+	–	+

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Leucopogan planifolius	Nov	+	–	–
Leucopogon pulchellus	July	–	+	+
Styphelia tenuiflora	Apr	+	+	–
LOGANIACEAE				
Logonia campanulata	Dec–Jan	+	–	–
PRIMULACEAE				
* *Anagallis arvensis* var. *caerulea*	Sept–Oct	–	+	+
LAMIACEAE				
Hemigenia sericea	Sept–Oct	+	–	+
SCROPHULARIACEAE				
Bellardia trixago	Oct	–	–	+
RUBIACEAE				
Opercularia vaginata	Aug	+	–	–
LOBELIACEAE				
Isotoma hypocrateriformis	Oct	+	–	–
GOODENIACEAE				
Dampiera linearis	Sept–Dec	+	–	–
Goodenia caerulea	Dec	+	–	–
Goodenia fasciculata	Sept–Oct	–	–	+
Scaevola platyphylla	Sept–Nov	+	–	–
Lechenaultia biloba	Sept–Dec	+	–	+
STYLIDIACEAE				
Stylidium amoenum	Oct	+	–	+
Stylidium brunonianum sub sp. *brunianum*	Sept–Dec	+	–	–
Stylidium bulbiferum	Dec	+	–	–
Stylidium calcaratum	Sept	–	+	+
Stylidium hispidum	Sept–Oct	+	–	+
Stylidium repens	Apr	–	–	+
Stylidium schoenoides	Sept	+	+	–
ASTERACEAE				
* *Arctotheca calendula*	Sept	+	–	–
Brachycome iberidifolia	Sept	+	–	+
* *Centaurea calcitrapa*	Sept–Dec	–	+	–
Helichrysum lindlei	Sept	–	+	–
Helipterum cotula	Sept–Mar	+	+	+
Helipterum craspedioides	Sept	–	+	–
* *Hypochoeris radicata*	Dec	+	+	–
Olearia paucidentata	May–Aug	+	–	+
* *Ursinia anthemoides*	Sept	–	+	+
Waitzia paniculata	Sept–Oct	–	–	+
Waitzia suaveolens	Jan	–	–	+